Short-term Changes in a Cottonwood-Ash-Willow Association on a Grazed and an Ungrazed Portion of Little Ash Creek in Central Arizona

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Abstract

Recovery of a cottonwood-ash-willow association from overgrazing has been extremely limited over a 4-year period. Seedling reproduction and herbaceous cover has increased; however, overstory tree species composition has not changed. Tree growth was not affected by grazing. The younger, associated, codominant tree species differed in composition between the grazed and ungrazed plots.

Grazing is generally thought to have a negative impact on riparian zones (Ames 1977, Davis 1977, Platts 1979, Thomas et al. 1979). The reproduction of many riparian tree species is oftentimes virtually eliminated by grazing because young seedlings are preferred browse for cattle (Glinski 1977, Martin 1979). In order to document the effects of grazing on riparian vegetation, numerous exclosures have been set up in the riparian zones of the National Forests, in Arizona (Turner et al. 1980). This study examines recovery within one such exclosure, 2 and 4 years after fencing.

Site Description

The study area is along the Little Ash Creek on the Prescott National Forest, about 14.5 km east of Cordes, Ariz., at a longitude of 112°02'30" west and latitude of 34°23'10" north (T12N R3E S33-34). The study area is divided into 2 sections by an exclosure originally set up in 1975 to protect the riparian vegetation from cattle. The study site within the exclosure is at an elevation of 1,165 m and the grazed study area is at 1,170 m. Both are in one of 3 range units, of approximately 3,300 ha each, that are grazed in rotation by a cow-calf herd of about 300 animal units. Riparian habitat represents less than 5% of the pasture where the study plots are located. Before 1975, both areas were subject to the same grazing pressure. After 1975, cattle were excluded from within the exclosure but not from the remainder of the drainage. The exclosure itself is approximately 16.5 ha (40 acres). The remainder of the pasture was grazed from March through June 1975 with 300 head of cattle and then again with 150 head in September and October. Thereafter, 300 head were grazed in November and December 1976, March through June 1977, November to February 1977-78, June through October 1978, and November through February 1979-1980. Average annual rainfall is about 430 mm (17 inches); June-September rainfall makes up 42%, and November-March precipitation 44% of the year's total.

Methods

Two study sites along Little Ash Creek were selected—one within the livestock exclosure and the other 100 m upstream of the

exclosure boundary. Four plots, 5- by 25-m, were selected parallel to the stream bed at each site. The initial plot was randomly located within the woody riparian vegetation, halfway between the stream bed and the outside edge of the riparian stringer. The remaining three plots at each site were placed linearly along the stream course at least 5 m from the boundary of the previous plot, excluding any major flood damaged areas to avoid areas of differing overstory.

The vegetation sampling technique was a modification of that used by Daubenmire and Daubenmire (1968) in their analysis of forest vegetation of Washington and Idaho. On each 5- by 25-m macroplot, all trees greater than 2.5 cm d.b.h. were measured. Relative density, relative dominance, relative frequency, and importance value were estimated using the formulas given by Cottam and Curtis (1956). Woody stems smaller than 2.5 cm d.b.h. but taller than 1 m were recorded as saplings. Those less than 1 m tall were considered as seedlings and were counted in two 1- by 25-m strips on each side of the macroplot. Twenty 20- by 50-cm microplots were established at 2.5-m intervals along the long edges of the macroplot, with 10 microplots along each edge. Crown canopy of each herbaceous species was recorded as a percentage of the microplot area. Forest overstory density was measured using a modified spherical densiometer (Lemmon 1956, 1957). Only the 12 squares forming a plus pattern at the front of the densiometer were used, in order to get a more directional reading. Density readings were taken at the 4 corners of each macroplot looking diagonally towards the opposite corner. The same macroplots on both study sites were sampled on June 8, 1977, and again on June 6, 1979. Differences in radial tree growth in each size category and herbaceous cover were tested with the *t*-statistic. Differences in canopy cover between years and plots were tested with a 2-way analysis of variance (ANOVA) (Sokal and Rohlf 1973).

Results

The primary tree species on both the ungrazed and grazed plots were Fremont cottonwood (*Populus fremontii*), velvet ash (*Fraxinus velutina*), and Goodding willow (*Salix gooddingii*) (Table 1). All other tree species were exclusive to one area or the other. Desert willow (*Chilopsis linearis*), Arizona walnut (*Juglans major*), and Rocky Mountain juniper (*Juniperus osteosperma*) were found only on the ungrazed plot. In contrast, netleaf hackberry (*Celtis reticulata*), Arizona sycamore (*Platanus wrightii*), velvet mesquite (*Prosopis juliflora*), and California buckthorn (*Rhamnus californica*) were present only on the grazed site. Because a number of stems of California buckthorn were greater than 2.5 cm d.b.h. by 1979, it was the only species to show a significant change in importance value for any tree species on either site.

Shrubs, saplings, and seedlings differed on both sites. The ungrazed area had 10 velvet ash and 2 cottonwood seedlings and some barberry (*Berberis haematocarpa*), fly thicket (*Brickellia*

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Table 1. Tree species importance values on grazed and ungrazed plots, along Little Ash Creek, Ariz., in 1977 and 1979.

Tree species	Ungrazed		Grazed	
	1977	1979	1977	1979
<i>Celtis reticulata</i>			10.4	9.9
<i>Chilopsis linearis</i>	21.7	20.7		
<i>Fraxinus velutina</i>	68.5	70.4	93.5	90.6
<i>Juglans major</i>	8.3	8.3		
<i>Juniperus osteosperma</i>	8.3	8.3		
<i>Platanus wrightii</i>			10.2	9.9
<i>Populus fremontii</i>	150.6	148.9	125.5	119.3
<i>Prosopis juliflora</i>			11.5	10.9
<i>Rhamnus californica</i>			0	17.4
<i>Salix gooddingii</i>	43.0	43.6	50.0	43.3

sp.), and desert ceanothus (*Ceanothus greggi*) not found on the grazed site. The grazed site had 43 California buckthorn shrubs and seedlings on the macroplots, whereas, only 1 California buckthorn seedling was found on the ungrazed macroplots. Moreover, the grazed macroplots had 14 juniper saplings and seedlings (*Juniperus deppeana* and *J. osteosperma*) whereas the ungrazed macroplots had only 5 juniper saplings and seedlings.

Percentage of herbaceous cover was significantly greater on the ungrazed microplots than the grazed microplots ($P \leq 0.05$, *t*-test) (Table 2). Percentage of cover also increased on both grazed (99%) and ungrazed (54%) plots from 1977 to 1979.

Tree growth was not affected by grazing practice (Table 3). Where size class comparisons are possible, average radial growth was not significantly different ($P \leq 0.05$, *t*-test) for the grazed versus ungrazed plots. There was, however, a definite difference in the size class distribution of Fremont cottonwood. On the grazed plot there were no cottonwoods with less than 22.5 cm d.b.h., whereas 48.3% of the cottonwoods on the ungrazed plot were less than 22.5 cm d.b.h. This difference is reflected in the percent gain in basal area between the two plots (Table 4). Total basal area (TBA) for cottonwoods on the ungrazed plot increased by 10% from 1977 to 1979, whereas on the grazed plot, TBA increased by 5.7% during

Table 2. Percent herbaceous cover on grazed and ungrazed plots on Little Ash Creek, Ariz. in 1977 and 1979.

Species	Ungrazed		Grazed	
	1977	1979	1977	1979
<i>Astragalus</i> spp.	0.2	0.1	+	0
<i>Andropogon barbinodis</i>	0.1	+	0	+
<i>Bouteloua curtipendula</i>	1.3	0.9	0.1	+
<i>Bromus</i> spp.	0.1	0.6	0	0
<i>Cynodon dactylon</i>	0	0	0.1	0
<i>Elymus glaucus</i>	0.1	1.3	0	0.3
<i>Erigeron divergens</i>	0	0	+	+
<i>Erigeron wrightii</i>	+	0	0	0
<i>Galium</i> spp.	+	0	0	0
<i>Gutierrezia sarothrae</i>	0.6	0.8	0.6	0.6
<i>Machaeranthera</i> spp.	0	0	0	+
<i>Melilotus alba</i>	0.8	0.7	0.3	1.3
<i>Muhlenbergia</i> spp.	0.2	0	0	0
<i>Panicum obtusum</i>	0	0.5	0	0
<i>Sitanion hystrix</i>	0	0.2	0	0
<i>Sonchus asper</i>	0	0.1	0	0
Total cover	3.4±0.8 ²	5.2±1.3	1.1±0.3	2.2±0.5

¹Indicates a trace presence in microplots.

²Mean ± standard error.

the same period.

On the grazed plot, canopy cover was 77.6±3.9% (S.E.) in 1977 and 78.5±3.2% in 1979. On the ungrazed plot, overstory canopy cover was 72.1±3.2% in 1977 and 74.2±3.3% in 1979. There were no significant differences in overstory canopy cover either between years or between plots (2-way ANOVA, $\alpha \geq 0.05$).

Discussion

The recovery of this riparian area from the effects of grazing has been limited by 3 major floods during the study period. Stream bank erosion has scoured the soil at least 0.5 m, exposing the upper roots of most tree species. Because of the close proximity of all the macroplots we feel that any effects due to flooding were similar on

Table 3. Average radial growth (millimeters) for the dominant riparian trees along Little Ash Creek, Ariz.

Tree species	Size classes (cm)				
	2.5≤d.b.h.<7.5	7.5≤d.b.h.<15.0	15.0≤d.b.h.<22.5	22.5≤d.b.h.<45	45≤d.b.h.
Ungrazed plot					
<i>Fraxinus velutina</i>	0.86±0.16 (14) ¹	0.60±0.12 (9)	1.10	—	—
<i>Populus fremontii</i>	1.40	1.77±0.23 (6)	1.76±0.69 (7)	1.22±0.28 (13)	2.8±0.00 (2)
<i>Salix gooddingii</i>	—	0.75±0.75 (2)	1.90±0.50 (2)	0.93±0.09 (3)	—
Grazed plot					
<i>Fraxinus velutina</i>	0.85±0.18 (11)	0.62±0.14 (10)	0.73±0.03 (4)	1.10±0.00 (1)	—
<i>Populus fremontii</i>	—	—	—	1.05±0.22 (8)	2.10±0.80 (3)
<i>Salix gooddingii</i>	2.7	—	—	1.63±0.61 (4)	—

¹Mean radial growth ± standard error (N).

Table 4. Overall growth of dominant riparian tree species along Little Ash Creek, Ariz. from 1977 to 1979.

Tree species	Total basal area (m ² /ha)		Net gain (m ² /ha)	Percent gain	Absolute density (trees/ha)
	1977	1979			
Ungrazed plot					
<i>Fraxinus velutina</i>	3.0± 0.8	3.5± 1.0	0.46±0.19	15.2	440±136
<i>Populus fremontii</i>	34.3± 5.2	37.8± 5.3	3.46±0.36	10.2	540±151
<i>Salix gooddingii</i>	5.9± 2.3	6.5± 2.5	0.59±0.28	10.1	120± 52
Grazed plot					
<i>Fraxinus velutina</i>	5.3± 1.8	5.9± 2.0	0.62±0.23	11.7	520±256
<i>Populus fremontii</i>	38.3±12.9	40.4±13.3	2.18±0.65	5.7	220± 20
<i>Salix gooddingii</i>	6.4± 4.5	7.1± 4.8	0.70±0.37	10.9	100± 50

¹Mean of Values from the four macroplots ± standard error.

all macroplots.

Herbaceous cover was at least double that on the ungrazed plot than on the grazed plot, but still 95% of the total soil surface is bare sand or gravel. This agrees with the data of Crouch (1978), who found a much greater cover of grasses and forbs on an ungrazed versus a grazed cottonwood bottomland in northeastern Colorado. The difference in herbaceous cover is not a result of a difference in overstory cover, because both sites had equal overstory cover values. It is probably a result of differences in grazing pressure.

Information on riparian tree species growth is extremely limited. Average radial growth in plains cottonwood (*Populus deltoides* var. *occidentalis*) ranges from 1.7 to 2.5 cm a year in dry habitats, and up to 7.0 cm a year in wet habitats (Fowells 1965). The growth of Fremont cottonwood in this study was similar to that of plains cottonwood on dry sites. In northeastern Colorado, basal area decreased on a grazed plot 18% but increased 16% on an ungrazed plot (Crouch 1979). Along Little Ash Creek, basal areas increased on both sites from 1977 to 1979. However, a look at tree size distribution indicates many more younger cottonwoods on the ungrazed site as well as some stand reproduction. One might expect continued increases on the ungrazed plot for a long period but a decrease on the grazed plot as the older trees decline. All the trees on both study sites probably were present before the establishment of the enclosure, with the possible exception of the single cottonwood in the smallest size class. Crouch (1979) estimated that an 18-cm d.b.h. cottonwood is approximately 30 years old. Cottonwood and ash seedling reproduction, however, is higher on the ungrazed plot, further indicating the potential recovery of this area from grazing, particularly because cottonwood and ash seedlings are known to be sought-after browse (Glinski 1977, Martin 1979).

In conclusion, differences between these two sites, primarily resulting from the exclusion of grazing pressure, are subtle at present. This indicates that a more complete recovery will require many more years of grazing protection.

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